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DEVELOPMENT OF A SOLUTION FOR OLED DISPLAY SMARTPHONES FOR PILOT TRAINING IN LOW-VISIBILITY FLIGHT SCENARIOS

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Abstract

Visual illusions and spatial disorientation are common causes of air accidents and incidents, especially during low-visibility flight conditions in small aircraft. It is therefore essential that pilots receive training regarding adaptation of the visual and vestibular systems to the aerospace environment. This project aimed to develop a device capable of simulating different visual illusions and aspects related to central and peripheral vision (colour and visual acuity), through the use of smartphones with OLED display technology (model: Galaxy S5 SM-G900M, screen: 5.1 inches, 1080 x 1920 pixels resolution, 432 pixels per inch). The phone was coupled with augmented reality glasses (model: ColorCross 3D Virtual Reality) with a 70 mm focal length lens, supporting devices of 4 to 6 inches. The smartphone is attached to the front of the glasses, giving an impression of three-dimensionality, and the visual tests are either transmitted from a computer or saved on the device itself. The images and videos selected, such as the Farnsworth-Munsell 100 Hue Test and Cambridge Colour Test, are commonly used in pilot training and are validated for use in clinical ophthalmology. Technical adaptations were necessary so these tests functioned adequately on the smartphone. Both tests are designed exclusively for use on a computing platform and, therefore, the Trinus VR application was first used to convert the computer image to 3D, before making it available on the smartphone screen. This solution for training pilots in visual illusions during low-visibility flight scenarios using smartphones with OLED displays is easy to implement, user-friendly and low-cost. Mobile technology adaptation for use in aviation training is of great value, as it can have a positive influence on the reduction of human errors that can result from alterations in human

physiology secondary to exposure to the aerospace environment, thereby reducing the occurrence of air accidents and incidents.

Keywords: Aviation medicine; aerospace physiology

Introduction

In 2000 the John Ernstring Aerospace Physiology Lab and the Aerospace Engineering Lab, both laboratories of the MicroG Centre, and the School of Aeronautical Sciences, PUCRS-Brazil, established an aerospace physiological training course for pilots and pilot students. The course includes basic life support training using a cardiopulmonary resuscitation mannequin, hypoxia exposure by means of breathing through a mask that delivers a gas with decreased oxygen concentration, spatial disorientation in a Barany's chair and visual illusions through individual, portable dark chambers (patent number MU 8200234-7, 09 August 2011).¹ The dark chambers used are bulky and the applied tests require pre-preparation with special card images, with manual control of brightness. Therefore, the need for a new and updated visual test system was proposed.

The main goal of aerospace physiology training, whether within a flight school or university setting, is to improve awareness of human physiological changes and adaptations to the aerospace environment. It also permits the individual to experience some aspects of flying in hostile scenarios, such as in low-visibility or night flight conditions. Therefore, the main focus of this training is to promote a better understanding of spatial disorientation and visual illusions during flight, and to provide a learning environment whereby pilots can safely acquire skills to deal with such situations.¹ However, despite huge efforts in spatial disorientation research, hardware development and training, the operational impact it has in terms of crew and aircraft

losses remains significant.² A study analysing 72 spatial disorientation mishaps involving US Air Force personnel reported a loss of 101 lives and 65 aircraft during the period from 1993 to 2013, with a total monetary cost of \$2.32 billion.³

The vestibular system and the eyes are very important sensory organs of spatial orientation, with both playing an essential role in aviation, especially during night or low-visibility flights. When one or both systems are affected, accidents or incidents can occur.⁴

On the ground, the essential requirement to remain orientated is a largely subconscious activity. In flight, orientation requires a conscious effort by the pilot, particularly when the visual environment becomes degraded and a deceptive force environment becomes the frame of reference. Visual illusions occur when a pilot's eyes are deceived into making a faulty assessment of aircraft position or orientation in relation to the external environment, caused by a misinterpretation of exterior visual stimuli. This can result in a misidentification of height, distance and/or intercept angles.⁵

There are two distinct visual systems: focal (central, cones and colour) and ambient (peripheral, rods) vision. Colour vision depends on the functioning of 3 photoreceptor cells (blue, green and red cones) that respond to different wave lengths. Colour blindness or colour vision deficiency is the decreased ability to see colour or differences in colour. The most common cause of colour blindness is a fault in the development of one or more of the three sets of colour sensing cones in the eye. Men are more likely than women to be colour blind, as the genes responsible for the most common forms of colour blindness are found on the X chromosome.¹

In order to educate pilots to better understand visual illusions, colour blindness and how to overcome their negative impact on flight safety, several different types of training devices have been developed for use alone (vision only) or in combination with vestibular system stimulation (linear and angular acceleration). Therefore, the present project aimed to develop a low-cost and portable device, capable of simulating different visual illusions (especially those commonly encountered during flight), as well as aspects related to central and peripheral vision (i.e., Daltonism), through the use of smartphones with OLED display technology, with the intention of contributing to pilot

training protocols. The device should be suitable for use alone or in combination with other aerospace physiological training aspects, such as spatial disorientation (Barany's chair) or hypoxia exposure.

Methods

The phone (model: Galaxy S5 SM-G900M, screen: 5.1 inches, 1080 x 1920 pixels resolution, 432 pixels per inch) was coupled with augmented reality glasses (model: ColorCross 3D Virtual Reality) with a 70 mm focal length lens, supporting devices of 4 to 6 inches. The smartphone was attached to the front of the glasses, giving an impression of three-dimensionality, with visual tests being transmitted either from a computer or saved on the device itself.

The images and videos selected, such as the Farnsworth-Munsell 100 Hue Test and Cambridge Colour Test, have previously been used in pilot training and validated for use in clinical ophthalmology.⁶ Technical adaptations were necessary so ensure their adequate functioning on the smartphone. Both tests are designed exclusively for use on a computing platform and, consequently, the Trinus VR application was first used to convert the computer images to 3D, before making them available on the smartphone screen.

The selected Farnsworth-Munsell 100 Hue Colour Vision Test consists of 4 distinct rows of small squares of different colours: row one ranges in colour from red to yellow; row two from yellow to green; row three from green to blue; and row four from blue to red. The aim of the test is to order the small squares in the correct order of progressive tones. Any misplacement can indicate some sort of colour vision deficiency.⁶

A common visual illusion occurring during night or low-visibility flight is the autokinetic effect (autokinesis), in which a stationary, small point of light against a dark or featureless environment appears to move. This effect is demonstrated by having 3 small light-emitting diode (LED) lamps in a very dark indistinctive environment. Only one LED is activated at the beginning of the test. This creates the illusion that the light is moving, albeit a minor movement, either being displaced from side to side or up and down. As soon as the viewer has perceived this "false" movement, the remaining 2 LEDs are activated, giving reference points to the viewer, who can then identify that the 3 LEDs are stationary.

Results

Since 2000, around 1,500 student pilots from the School of Aeronautical Sciences, PUCRS, have completed the aerospace physiological training course as part of their school curriculum, including the colour vision tests and visual illusions during low-visibility and night flight simulations. The training program was conducted at the John Ernsting Aerospace Physiology Lab of the MicroG Centre, PUCRS. Individual, portable dark chambers were originally used, which have now been substituted by the smartphones with OLED display technology. Both systems were developed by the Aerospace Engineering Lab of the MicroG Centre.

The combination of smartphone with augmented reality glasses resulted in a lighter and smaller system, and therefore more portable than the original dark chambers. The visual tests used present greater variety, as they can be transmitted from a computer or even saved directly onto the mobile phone itself. Colour and brightness proved to be easily adjustable in order to conform to the required conditions of the test. More precise control of the level of brightness or darkness applied is possible, in comparison to the dark chambers.

This solution for training pilots in visual illusions during low-visibility and night flight scenarios using smartphones with OLED displays is easy to implement, user-friendly and low-cost.

Conclusion

Aerospace physiological training has benefited greatly from the development of several Internet-based and computer science software, as they allow the use of digital technology in the simulation of different flight manoeuvres and environments. The application of digital technology to devices for pilot training in spatial disorientation and visual illusions has made them more reliable, cost-effective and easy to use. Mobile technology adaptation for use in aviation training is, therefore, of great value. It can improve pilot skills, having a positive influence in diminishing human errors resulting from alterations in human physiology secondary to exposure to the aerospace environment, thereby reducing the occurrence of air accidents and incidents.

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Conflict of interest. The authors declare no conflicts of interest.

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